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Effectiveness of two dimensional virtual reality programme and computer-assisted instructional programme in training Mass Transit Railway (MTR) skills for persons with mental handicap: A pilot study

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Objectives: To compare the effectiveness of a dimensional virtual reality programme (2DVR) and computer-assisted instructional programme (CAI) in training Mass Transit Railway (MTR) skills for persons with mental handicap (MH).
Study design: Pre-test and post-test quasi-experimental design was adopted.
Methods: Eighteen persons with mild mental handicap were randomly assigned to three groups: the 2DVR programme, the CAI programme and the control group. Each training programme consisted of six sessions held over a 4-week period.
Results: Both the 2DVR and the CAI groups showed significant improvement in their MTR skills ($p = 0.028$ and $p = 0.028$, respectively) when compared with that of the control group ($p = 0.498$). There were also significant differences between the post-assessment scores as measured by the behavioural MTR skills among the groups ($p = 0.005$).
Conclusions: The 2DVR and CAI programme appeared to be an effective strategy for training MTR skills of persons with mild to moderate graded mental handicap.

KEY WORDS: Computer assisted instruction • MTR skills • 2 dimensional virtual reality

Introduction

There have been preliminary reports indicating that two dimensional virtual realities (2DVR) may be a useful tool for rehabilitation (Ross, Attree & Johnson, 1996; Rizzo et al., 1997; Trepagnier, 1999; Wiederhold & Wiederhold, 2000; Schultheis, 2001). Many studies have been completed in applications and evaluations of 2DVR, especially on the assessment, treatment, and functional outcomes (Cunningham & Krishack, 1999; Moffat et al., 1998; Riva, 1998; Riva et al., 1999; Rizzo et al., 2000; Schultheis & Rizzo, 2001). 2DVR was anticipated as an effective means of improving the prerequisites for competent transport skills, such as improving the perceptual-motor skills, including attention (Wann et al., 1997). Training using a virtual environment can also improve basic navigation skills, such as extracting information and forming mental representations (Darken et al., 1999), accurate predictions of movements, and accurate estimations of distance and direction (Loomis et al., 1992).

On the other hand, a comprehensive review by Niemiec and Walberg (1987) reported median score results of 92% of studies favoured computer-assisted instruction (CAI). This was further supported by a meta-analysis of 254 controlled-evaluation studies conducted by Kulik & Kulik (1991). They

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found that CAI programmes usually produced positive effects on learners. The effectiveness of CAI is believed to be due to its systematic, consistent and individualized instruction. The aim of the present study was to pilot the evaluation for the effectiveness of two new and innovative programmes: 2DVR and CAI in training Mass Transit Railway (MTR) skills in Hong Kong, for people with mild to moderate mental handicap (MH), who usually have difficulties in using community facilities. The effectiveness of both programmes was also compared and contrasted with that of a control group.

Method

Participants

Through convenience sampling, 18 participants were recruited from the Caritas Lok Kin Sheltered Workshop, Hong Kong. Subjects ranged from 18–28 years old, and with mild to moderate grade mental handicap. The selection criteria for participants included: 1) Diagnosed as mild to moderate mental handicap by medical practitioners; 2) aged above 18 years; 3) medically stable; 4) suffering from cognitive problems in areas such as memory, attention, problem-solving and organizational abilities; 5) have a basic attention span of 3 minutes or more; and 6) did not receive any previous training for the use of the MTR.

Procedures

The present study involved the development of a 2DVR and a CAI programme for training in the local context. Both programmes consisted of six sessions, and each session lasted 45 minutes with the same content and structure as in a realistic MTR skills training. A pre-test and post-test quasi-experimental research design was adopted to compare the training outcomes among the 2DVR programme, the CAI programme and the control group. In our study, 18 participants were randomly assigned into these three groups. Six participants received a six-session MTR skills training schedule, using a 2DVR programme. In this programme, the participants were guided to learn the basic MTR skills with the help of a software-based 2DVR system. Another 6 received a 6-session basic MTR skills training schedule for using CAI multimedia tutorials (i. e. PowerPoint), with feedback and verbal reinforcement. The third group was a control group, consisted of six participants. All the participants in the control group did not receive any training throughout the study.

Interventions

2DVR provides a two-dimensional computer representation of a real world or imaginary space, through which a person can navigate and interact with objects to carry out specific tasks (Crosbie *et al.,* 2005). This programme contains a simulated MTR environment. The participants can move around in the environment using a keyboard control. They can approach and use the different facilities in MTR. This programme allowed the participants to orientate, navigate and explore via the programmed software, in order to practice and learn the cognitive tasks such as how to purchase a ticket at the ticketing machine, pass through the gate, use the escalator, and identify the platform in the virtual environment (Figure 1).

The CAI instruction adopted the same structure and content as the 2DVR training. However, the difference was that the participants received consistent tutorial sessions, demonstration, role-play and verbal feedback by the use of PowerPoint and pictures from the trainer, rather than from a simulated environment. All training was conducted in an activity room. Games and role-plays were used to help them to practice the skills (Figure 2).

Figure 1. *Lobby of Mass Transit Railway station in two dimensional virtual reality programme*

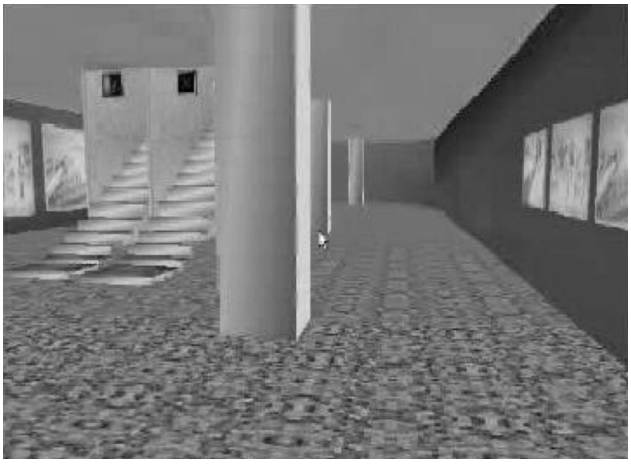

Figure 2. *Platform of Mass Transit Railway station in two dimensional virtual reality programme*

Instrumentation

A 30-item behavioural MTR-skills checklist was used to assess the participants' pre-test and post-test MTR skills. Items of the checklist included a comprehensive list of skills required in using the MTR in Hong Kong (Table 1). The MTR-skill checklist was modified from the supermarket checklist (Westling et al., 1990). This checklist contains items which break up the procedure of shopping in a supermarket into small steps. In this study, the procedures of traveling by MTR were also broken down into small steps. Five point scales were used to rank the independence of the participants when doing the steps. The results were analyzed using the behavioural MTR skill scores which is the summation of scores in all items.

At the end of the assessment each participant's performance was scored by the trainer according to the items in the checklist. The items were also classified into three main categories (recognition, judgment and procedure concept), and were divided and grouped into the categories in terms of the cognitive functions needed, providing a more detailed analysis of the training outcomes (Figure 3). A field test had been carried out for measuring two participants' performances by four occupational therapy students using the behavioural MTR skills checklist. The ratings of all the four students on the 2 participants were the same, which indicate the checklist is reliable among inter-raters.

Table 1. Mass Transit Railway skills with categories

Recognition	1. 可識別售票機 Able to recognize the vending machine
	3. 可識別售票機上目的地的位置 Able to recognize destination on panel
	5. 可確認所買車票的售價 Able to recognize the fare amount
	8. 可找出入錢處 Able to find the coin slot
	9. 可將錢幣放進入錢處 Able to put the coin in
	10. 可找到出票處 Able to find where to pick ticket up
	13. 可確認入閘口 Able to identify the gate
	15. 可確認入票口 Able to recognize the ticket slot
	16. 可放車票進入票口 Able to put ticket in
	18. 可確認扶手電梯的位置 Able to recognize the location of escalator
	20. 能識別正確月台的位置 Able to recognize the correct platform
	25. 可確認扶手電梯的正確位置 Able to identify the correct escalator
	28. 可確認入票口 Able to recognize the ticket slot
	30. 可確認正確出口Able to identify the correct exit
Judgment	4. 可選擇與按下正確的按鈕 Able to select and press on the right buttons
	7. 可找出正確的金額 Able to find correct amount of coin or money note
	19. 正確使用扶手電梯 Able to use the escalator safely
	22. 於黃線後等候列車 Able to recognize the yellow line and stay behind it
	23. 懂等候乘客下車後再上車 Able to enter train after passengers getting out
	24. 可安全地下車 Able to get off the train safely
	26. 正確使用扶手電梯 Able to use the escalator safely
	27. 可確認正確出口的位置 Able to identify the correct exit
Procedure concept	2. 可步行到售票機 Able to walk to the vending machine
	6. 可從散錢包中拿出錢幣 Able to reach for his money from wallet
	11. 可從出票處取出車票及所找續的零錢 Able to pick up the ticket and collect the
Charge	12. 將所找續的零錢安全地放進散錢包 Able to keep purse safely after picking the
Ticket	14. 可步行至正確的入閘口 Able to walk to correct gate
	17. 懂得通過入閘口 Able to push through gate
	21. 懂步行至正確的月台 Able to walk to correct platform
	29. 可通過正確閘口Able to put through the gate

Figure 3. Behavioural checklist in Mass Transit Railway skills (Westling et al, 1990)

Name of Client: _____

Name of Assessor: _____

Date of Assessment: _____ Total score: _____

Please tick '√' as appropriate

步驟 Steps	0	1	2	3	4	Comment
1. 可識別售票機 Able to recognize the vending machine						
2. 可步行到售票機 Able to walk to the vending machine						
3. 可識別售票機上目的地的位置 Able to recognize destination on panel						
4. 可選擇與按下正確的按鈕 Able to select and press on the right buttons						
5. 可確認所買車票的售價 Able to recognize the fare amount						
6. 可從散錢包中拿出錢幣 Able to reach for his money from wallet						
7. 可找出正確的金額 Able to find correct amount of coin or money note						
8. 可找出入錢處 Able to find the coin slot						
9. 可將錢幣放進入錢處 Able to put the coin in						
10. 可找到出票處 Able to find where to pick ticket up						
11. 可從出票處取出車票及所找續的零錢 Able to pick up the ticket and collect the charge						
12. 將所找續的零錢安全地放進散錢包 Able to keep purse safely after picking the ticket						
13. 可確認入閘口 Able to identify the gate						
14. 可步行至正確的入閘口 Able to walk to correct gate						
15. 可確認入票口 Able to recognize the ticket slot						
16. 可放車票進入票口 Able to put ticket in						
17. 懂得通過入閘口 Able to push through gate						
18. 可確認扶手電梯的位置 Able to recognize the location of escalator						
19. 正確使用扶手電梯 Able to use the escalator safely						
20. 能識別正確月台的位置 Able to recognize the correct platform						
21. 懂步行至正確的月台 Able to walk to correct platform						
22. 於黃線後等候列車 Able to recognize the yellow line and stay behind it						
23. 懂等候乘客下車後再上車 Able to enter train after passengers getting out						
24. 可安全地下車 Able to get off the train safely						
25. 可確認扶手電梯的正確位置 Able to identify the correct escalator						
26. 正確使用扶手電梯 Able to use the escalator safely						
27. 可確認正確出口的位置 Able to identify the correct exit						
28. 可確認入票口 Able to recognize the ticket slot						
29. 懂得通過入閘口able to put through the gate						
30. 可確認正確出口的位置able to identify the correct exit						

其他觀察到的行為：
Other behaviour(s) observed:

Scoring system:
0 = activity impossible
1 = direct instruction is given
2 = close end question is provided to give hints
3 = adequate performance, but assurance is needed
4 = normal performance

Implementation

There are six sessions in both the 2DVR and CAI groups. The first session consisted of introducing the programme and baseline assessment. In the second session, various display signs in the MTR were taught. Money concepts were taught in the third session, and purchasing a ticket by using a vending machine was taught in fourth session. Ways to get to the platform were taught in the fifth session, and in the last session, all the previous sessions were revised by running the whole procedure in the use of the MTR. Each session lasted for 45 minutes and the procedures of both groups were the same.

Data analysis was conducted using the Statistical Package SPSS, version 12.0 for Windows (SPSS Inc., Chicago, IL, USA). Owing to small sample size, non-parametric statistical method was used. Wilcoxon Signed Rank Test was used to evaluate the within-group difference of pre- and post-behavioural MTR skills scores, and the group comparisons on those three MTR skill categories. Mann-Whitney test was used to detect the differences between the pre-test and post-test scores of behavioural MTR skills checklist of all three groups. The improvement scores (Post-score – Pre-score) of 2DVR and CAI groups in the three categories were analysed using the Kruskal Wallis test. Levels of significance were set at 0.05.

Results

Outcomes of Within-group Comparisons

After receiving the training programmes, the participants within both groups showed statistically significant improvement in MTR-using skills. The results of Wilcoxon Signed Rank Test showed significant differences between the pre- and post-assessment scores within both the 2DVR training group and the CAI group ($p = 0.028$ and $p = 0.028$, respectively) (Table 2). In contrast, there was no significant difference between the pre- and post-assessment scores in the control group ($p = 0.498$). It could be concluded that both training programmes were effective in training people with MH in MTR using skills.

Outcomes of Between-group Comparisons

Mann-Whitney test was used to compare the between group differences of the three groups' pre-test and post-test behavioural MTR skills scores. There were no significant differences among the three groups at the baselines, prior to the intervention ($p = 0.079$) (Table 2). It was found that there were significant differences between post-assessment scores of the three independent groups ($p = 0.005$). Further evaluation by *post hoc* test of the three independent groups showed that there was a significant difference between the 2DVR and CAI training programmes to the control group, respectively ($p = 0.006$ and $p = 0.006$). However, there was no significant difference between 2DVR and CAI training programmes ($p = 0.290$) (Table 2). It could be concluded that 2DVR and CAI training programmes were equally effective in training people with MH in MTR skills.

Within-group Comparisons on MTR-skill Categories

The 30 behavioural MTR-skill items in the checklist were further categorized into three skill areas: recognition, judgment, and procedure. Using the Wilcoxon Signed Ranks test, there was a significant improvement in the categories of recognition skill and judgment skill in both 2DVR ($p = 0.028$ and 0.045, respectively) and CAI groups ($p = 0.028$ and 0.024, respectively) after interventions (Table 3). However, no statistically

Table 2. Results of between and within groups comparison for all groups*

	2DVR training ($n = 6$)		CAI training ($n = 6$)		Control ($n = 6$)	
	Pre-	Post-	Pre-	Post-	Pre-	Post-
Mean/ SD	81.5/12.06	109.67/2.34	65.67/21.62	107.17/4.39	90.33/6.62	90.6/6.99
Within group difference	Z = -2.201 $p = 0.028$		Z = -2.201 $p = 0.028$		Z = -0.677 $p = 0.498$	
	Pre-		Post-			
Between groups differences	Chi-Square = 5.071 $p = 0.079$		Chi-Square = 10.64 $p = 0.005$			
	2DVR and CAI training groups		2DVR and control groups		CAI and control groups	
Post hoc comparison	Z = -1.052 $p = 0.290$		Z = -2.757 $p = 0.006$		Z = -2.745 $p = 0.006$	

2DVR = two dimensional virtual realities; CAI = computer-assisted instruction

Table 3. Results of within group comparisons on MTR-skill categories for 2DVR and CAI groups

	SDVR training (n = 6)						CAI training (n = 6)					
	Recognition		Judgment		Procedure concept		Recognition		Judgment		Procedure concept	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	33.33	52.17	23.33	32.5	23.67	25.17	24.83	52.33	21.33	33.33	19.83	23.67
SD	10.21	3.31	4.68	4.38	8.19	2.71	24.87	2.42	4.84	7.39	4.07	2.07
Within-group differences	Z = –2.201 p = 0.028		Z = –2.003 p = 0.045		Z = –0.631 p = 0.528		Z = –2.201 p = 0.028		Z = –2.264 p = 0.024		Z = –1.363 p = 0.173	

MTR = Mass Transit Railway; 2DVR = two dimensional virtual reality; CAI = computer-assisted instruction

Table 4. Results of improvement score comparison between SDVR and CAI groups in divided categories of MTR skills

	Recognition	Judgment	Procedure concept
2DVR group (Mean of Post – Pre score)	18.84	9.16	1.49
CAI group (Mean of Post – Pre score)	27.5	11.97	3.83
Between-group differences (2DVR and CAI)	Chi-square = 1.653 p = 0. 199	Chi-square = 0.322 p = 0.57	Chi-square = 0.006 p = 0.936

MTR = Mass Transit Railway; 2DVR = two dimensional virtual reality; CAI = computer-assisted instruction

significant difference was found in the procedure concept of both the 2DVR and CAI groups after receiving the training programmes (p = 0.528 and 0.173, respectively) (Table 3).

2DVR and CAI Group Comparison in Divided Categories

Kruskal Wallis Test was used to compare the improvement scores (Post score – Pre score) of 2DVR and CAI groups in the three categories, recognition, judgment and procedure concept. It was found that there was no significant difference between the improvement scores in all the three categories (p = 0.199–0.936) (Table 4). Further investigation on the values of the mean scores of these two groups found that the improvement in mean scores in category of recognition between pre- and post-assessment in both groups had obvious differences. The CAI group, which was 27.5 (Table 4), was larger than that of the 2DVR group, which was 18.84 (Table 4). That is, participants in CAI group seemed to show better recognition than those in the 2DVR group.

Discussion

This study compared the effectiveness of the 2DVR training programme and the CAI programme in training persons with mental handicap in MTR skills. Results indicated that both the 2DVR and the CAI programmes might help enhance the MTR skills of persons with mild to moderate mental handicap. The use of virtual environments enables participants with MH to have total control over the situation of stimulus. Since the performance feedback was immediate and consistent, the participants were less easily distracted in such a well-controlled virtual environment (Brooks et al., 1999; Rose et al., 2000). The provision of 'cueing' stimuli or visualization tactics was very useful in guiding the participants to perform the required skills more successfully (Rizzo et al., 1997). The 2DVR programme also allowed participants to learn in a safe and controlled environment that would minimize errors due to unexpected situations in the real world. In addition, it was possible for participants to click on part of the image and obtain immediate feedback about what they were looking at. Therefore, they did not have the feeling that they were lagging behind others in the learning process (Wharrad et al., 2001). Lastly, the 2DVR programme allowed participants a chance to learn and practice the required skills in an environment under their own control. This could enhance the confidence and performance of participants, as they need not face uncertainty due to unexpected situations.

Although there was no significant difference between the improvement scores when comparing 2DVR and CAI training groups in the three categories as measured by the behavioural MTR skills checklist, comparison of the values of the mean scores in improvement between the two groups found that the CAI could help the subjects to achieve better skills in recognizing the MTR facilities for people with MH. In the study by Eberts & Brock (1987), CAI is best suited for factual

information with specified goals and objectives. In the CAI training group of this study, the materials were presented with the PowerPoint programme. The MTR facilities were discussed and explained thoroughly. This allowed participants of the CAI group to have a better understanding of the appearance and usage of the MTR facilities. CAI training also allowed the participants a longer time in studying the different MTR facilities, whereas in the 2DVR programme, it only allowed the participants to navigate in a virtual simulation of the actual environment. Therefore, the image of the facilities may not be exactly the same as the real one. Moreover, the programme used the Mongkok MTR station as the model for teaching. The clients may be confused when using the MTR in another other place, if they have poor generalization skills. In previous studies, it has been found that 2DVR training shows better results in procedural skills. However this was inconsistent with the results of our current study. This may due to the speed of implementation in the 2DVR programme. Since the flow of the 2DVR programme was scheduled, the content of each session were previously set. Therefore, it may not fit the pace of all the participants, and may thus affect their learning. In future research or training, the time control of the 2DVR programme must be carefully preset.

Limitations

The present study has several limitations that might affect its results. First, the sample size was small, which might increase the errors by chance. The lack of follow-up measurement limited the generalization of the study results. For the 2DVR programme, since some participants were not familiar with the computer operation, it may have affected their training outcomes. It is recommended that rehearsals should be provided for people with MH in future studies. Moreover, heterogeneity of participants' educational levels and previous MTR experiences, and absence of participants in sessions might have also affected the training outcomes.

Conclusions

Both 2DVR and CAI programme were found to be effective in training for MTR skills of people with MH. The present results are consistent to findings from previous studies on using CAI and 2DVR strategies in community living skills training (Rizzo, 2000; Tam *et al*., in press). Besides being a complement of the conventional training method, the 2DVR rehabilitation programme can be further developed as an effective alternative of conventional programmes in the near future. Further research in this area is recommended in order to further confirm its efficacy on facilitating community integration of people with MH.

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